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## Agricultural Water Management Plan Worksheets

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## **Introduction**

The California Department of Water Resources, in cooperation with the Agricultural Water Management Council, has developed a set of worksheets to assist with the preparation of an agricultural water management plan. These worksheets were developed using the Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers in California.

DWR has developed this set of worksheets for two purposes. The first is to aid a water supplier preparing its AWMP. The second is to guide DWR staff with the review of submitted plans.

The worksheets may not completely meet the planning needs of your agency or your community. DWR has tried to excerpt provisions to assist a water supplier with the creation of its AWMP. However, the MOU is complex and subject to change. In case of any conflict between the representation of the MOU in these worksheets, and the language of the MOU, the MOU language shall have precedence.

DWR suggests a water supplier using these worksheets review the whole package before beginning.

## **Contents of Package**

The worksheets are organized according to the steps set forth in the MOU. Whenever possible, the worksheets discuss a topic of the MOU on one page. Each topic is formatted the same. The topic has the MOU quoted at the top of the page and checkboxes follow the quotation. Each checkbox highlights a discrete point in the MOU.

Many of the topics contain tables. DWR provides the tables to demonstrate a concise and effective method of addressing the information identified in the UWMPA. While these worksheets attempt to break the MOU into discrete topics, a water supplier should not understate the value of integrated comprehensive planning.

These worksheets do not refer to the efficient water management practices discussed in Step 5 of the MOU. DWR has developed a separate set of Excel worksheets to respond to the EWMPs.

## **AWMP Review**

DWR is cooperating with the Agricultural Water Management Council to develop a review process for the AWMPs.

## Step 1: Agency Coordination and Public Participation

### MOU Guideline

**Intent:** To allow the submittal of joint WMPs and to ensure notification to interested parties that a WMP is being prepared.

**Step 1:** It is recommended that signatories with mutual needs work together to develop agreements /MOUs to prepare and/or implement its WMP. The signatory water supplier will include public participation in its WMP development and implementation. The WMP should describe how participation by interested parties (local, regional, State, and federal agencies; special districts; land use agencies; and citizens groups [business, environmental, social]) was solicited. The Council will maintain and provide, upon request, a list of interested parties that the water supplier can notify about WMP preparation.

The WMP should describe mutual agreements/MOU with other signatories or agencies and specific public participation.

### Compliance Provisions

- ☐ Provide a description of specific public participation involvement (Table 1)
- ☐ Provide a description of solicitation efforts to encourage public participation (Table 1)
- \*Completing this provision will also complete the identification of WMP development in Step 7.
- ☐ Provide a description of mutual agreements/MOUs with other signatories or agencies

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 1. Solicitation/Participation by Interested Parties						
Potential Interested Parties	Notified of Plan Preparation	Requested a Copy of Draft	Commented on Draft	Notified of Public Meetings	Attended Public Meetings	Notified of Intention to Adopt
Local government agency						
Special districts						
Regional agency						
Environmental citizen group						
Land Use Agencies						
Business group						
Social citizen group						
State government agency						
Federal government agency						
Other						
Other						

## Step 2A: History and Size

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2A:** Give an historical overview of the water supplier by including the following information: date of formation, source of water supply, gross acreage, and present irrigated acreage.

### Compliance Provisions

- ☐ Provide the date of formation (Table 2)
- ☐ Provide the source of water supply (Table 2)
- ☐ Provide the gross acreage (Table 2)
- ☐ Provide the present irrigated acreage (Table 2)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 2. Water Supplier History and Size	
Date of Formation	
Source of Water at Time of Formation	
Local Surface Water	
Local Groundwater	
Wholesaler	
USBR	
SWP	
Gross Acreage at Time of Formation	
Present Irrigated Acreage	

## Step 2B: Location and Facilities

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2b:** Describe the water conveyance and delivery system within the service area by including the following information about the water delivery system: miles of unlined canals, miles of lined canals, mile of pipelines, miles of drains, the total number and total capacity of all reservoirs, whether a tailwater/spill recovery system exists, and what type of delivery system is used. Provide a map of the service area showing, where possible, existing water diversion(s), distribution and drainage facilities, and water measurement devices.

Describe any additional information, as needed, to further clarify the water supplier's delivery system.

If the water supplier has restrictions on its water source(s) that result(s) in operational constraints, describe the restriction and how it effects the water delivery operations.

If the water supplier's service area is expected to materially change within the next five years, describe the expected change.

### Compliance Provisions

- ☐ Quantify the miles of unlined canals (Table 3)
- ☐ Quantify the miles of lined canals (Table 3)
- ☐ Quantify the miles of pipelines (Table 3)
- ☐ Quantify the miles of drains (Table 3)
- ☐ Quantify the total number and total capacity of reservoirs in the service area (Table 4)
- ☐ Indicate existence of tailwater/spill recovery system(s) (Table 5)
- ☐ Identify type of water delivery system (Table 6)
- ☐ Provide a map of the service area

### If Applicable

- ☐ Provide a description of restrictions on water sources that cause operational constraints and/or affect water delivery operations. (Table 7)
- ☐ Provide a description of any expected material change of the service area within the next five years. (Table 8)

**Step 2B: Location and Facilities (continued)****Example Format**

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 3. Water Conveyance and Delivery System	
System Used	Number of Miles
Unlined Canal	
Lined Canal	
Pipelines	
Drains	

Table 4. Supplier Reservoirs	
Number	
Total Capacity	

Table 5. Tailwater/Spill Recovery System	
System	Yes/No
District Operated Tailwater/Spill Recovery	
Grower Operated Tailwater/Spill Recovery	

Table 6. Supplier Delivery System	
Type	Check if Used
On Demand	
Modified Demand	
Rotation	
Other	

**Step 2B: Location and Facilities (continued)****Example Format**

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

<b>Table 7.</b> <b>Restrictions on Water Sources</b>		
<b>Restrictions</b>	<b>Name of Agency Imposing Restrictions</b>	<b>Operational Constraints</b>

<b>Table 8.</b> <b>Expected Changes to Service Area</b>	
<b>Change to Service Area</b>	<b>Affect on the Water Supplier</b>
Reduced Service Area Size	
Increased Service Area Size	
New Governmental Entity	
Other	

## Step 2C: Terrain and Soils

### MOU Guideline

**Intent:** To describe general physical information about the water supplier's service area in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2C:** Describe the topography of the water supplier's service area (i.e., hilly, flat, sloping to a water course). Indicate the impact of topography and soil conditions on water operations and management within the water supplier service area.

### Compliance Provisions

- ☐ Identify any impacts the topography has upon water operations and management in the service area (Table 9)
- ☐ Identify any impacts that the soil characteristics have upon water operations and management in the service area (Table 10)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 9. Topography Impacts	
Topography Characteristic	Impact of Water Operations

Table 10. Soil Characteristic Impacts	
Soil Characteristic	Impact of Water Operations

## Step 2D: Climate

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2D:** Describe the general climate of the water supplier. Include average precipitation, and maximum and minimum temperatures. If areas within the water supplier's service area are known to have significantly different microclimates, describe how they affect water management decisions and operations.

### Compliance Provisions

- ☐ Provide a description of general climate characteristics including the minimum and maximum temperature, and average precipitation (Table 11)

### If Applicable

- ☐ Provide a description of significantly different microclimates and their affect on water management decisions and operations

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 11. Climate Characteristics	
Climate Characteristic	Annual Value
Average Precipitation	
Minimum Temperature	
Maximum Temperature	

## Step 2E: Operating Rules and Regulations

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2E:** Describe or attach a copy of the water supplier's operating rules and regulations, including water allocation policy, lead time necessary for water orders and water shut-off, any policies regarding return flows, and/or drainage leaving the water supplier's service area, as appropriate.

### Compliance Provisions

- ☐ Attach a copy of the operating rules and regulations that includes the water supplier's water allocation policy, lead time necessary for water orders and water shut-off and any policies regarding return flows and/or drainage flows leaving the service area

**OR**

- ☐ Provide a description of the water allocation policy (Table 12)  
☐ Provide the lead time necessary for water orders and water shut-off (Table 13)  
☐ Provide a description of any policies regarding return flows and/or drainage flows leaving the service area

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 12. Water Allocation Policy				
Basis of Water Allocation	(Check if applicable)			Normal Year Allocation
	Flow	Volume	Seasonal Allocations	
Area within the service area				
Amount of land owned				
Riparian rights				
Other				

Table 13. Actual Lead Times	
Operations	Hours/Days
Water orders	
Water shut-off	

## Step 2F: Water Delivery Measurements or Calculations

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2F:** Describe how water deliveries to customers are currently measured or calculated. Describe the frequency and types of measurement (meters, calibrated weirs, meter gates, other), levels of accuracy, frequency of calibration, and frequency of maintenance.

### Compliance Provisions

- ☐ Identify the frequency of water measurement (Table 14)
- ☐ Identify the types of measurements used (Table 14)
- ☐ Identify the levels of accuracy (Table 14)
- ☐ Identify the frequency of calibration (Table 14)
- ☐ Identify the frequency of maintenance (Table 14)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 14. Water Delivery Measurements				
Measurement Device	Frequency of Measurement (Days)	Frequency of Calibration (Months)	Frequency of Maintenance (Months)	Estimated Level of Accuracy (%)
Orifices (meter gates)				
Propeller Meters				
Weirs				
Flumes				
Verturi Meters				
Pump, Run Time				
Pump, KWH				
Other				

## Step 2G: Water Rates Schedules and Billing

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2G:** Describe the basis for water charges for agricultural uses. A copy of the water supplier's written operating rules and regulations will suffice if they describe the basis for water charges (i.e., by quantity, acre, crop, land assessment, or other charges).

If water use is billed by quantity, describe the rate structure (i.e., declining, uniform, or increasing block rate). Include the billing frequency (i.e., monthly, bimonthly, annually).

### Compliance Provisions

☐ Attach a copy of the rules and regulations which contain a description of the basis for water charges

**OR**

☐ Provide a description of the basis for water charges (Table 15)

### If Applicable

☐ Provide a description of rate structure when billing is by quantity (Table 16)

☐ Provide a description of billing frequency when billing is by quantity (Table 17)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 15. Water Rate Basis	
Water Charge Basis	Check if Used as Basis
Quantity	
Acre	
Crop	
Land Assessment	
Other	

**Step 2G: Water Rates Schedules and Billing (Continued)**

<b>Table 16. Rate Structure</b>	
<b>Type of Billing</b>	<b>Check if Used</b>
Declining	
Uniform	
Increasing Block Rate	
Other	

<b>Table 17. Frequency of Billing</b>	
<b>Frequency</b>	<b>Check if Used</b>
Weekly	
Biweekly	
Monthly	
Bimonthly	
Semiannually	
Annually	

## Step 2H: Water Shortage Allocation Policies

### MOU Guideline

**Intent:** To describe general physical information about the water supplier in order to form a basis for evaluating improvements by, and within, the service area, as well as to provide the basic information about physical aspects of the water supplier that may affect the potential for improved water management.

**Step 2H:** Does the water supplier have a water shortage allocation policy? If yes, attach a copy of the policy. If no, describe how reduced water supplies, including hardship water, are allocated. Describe any water supplier policies that address wasteful use of agricultural water and describe enforcement methods.

### Compliance Provisions

☐ Copy of policy is attached

**OR**

☐ Provide a description of how decreased water supplies, including hardship water, are allocated (Table 18)

☐ Provide a description of policies addressing wasteful use

☐ Provide a description of policies addressing enforcement methods (Table 19)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 18. Decreased Water Supplies Allocations	
Allocation Method	Check if used
By crop	
First come first served	
Area in district	
Other	
No specific policy	

Table 19. Enforcement Methods of Allocation Policies	
	Check if used
Fines	
Water Shut-off	
Other	
No specific policy	

## Step 3A: Surface Water Supply

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step 3A:** Briefly describe the nature and amounts of each of the water supplier's surface water supplies (i.e., pre-1914 water rights, CVP Class I water contract for agriculture, SWP water contract for agriculture, exchange contract). Describe any restrictions on the time of diversion. Describe any anticipated changes in the water supplier's surface water supplies during the next five years. Provide the amount of water received from each source for each of the last five years.

### Compliance Provisions

- ☐ Identify surface water supply sources (Table 20)
- ☐ Identify the volumes of each surface supply source for each of the last five years
- ☐ (Table 20)

### If Applicable

- ☐ Provide a description of any restrictions that occur on the time of diversion (Table 20)
- ☐ Provide a description of any anticipated changes in the surface water supplies within the next five years

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

<b>Table 20.</b> <b>Surface Water and Other Water Supply Sources</b> <b>(Acre-Feet)</b>							
<b>Source</b>	<b>Diversion Restriction</b>	<b>Quantity Five years prior</b>	<b>Quantity Four years prior</b>	<b>Quantity Three years prior</b>	<b>Quantity Two years prior</b>	<b>Quantity One year prior</b>	<b>Anticipated Changes</b>
Pre-1914 water rights							
CVP class I water contract							
SWP water contract							
Other imported water							
Local surface water							
Upslope drain water							
Transfers/Exchanges							
Other							
<b>Total</b>							

## Step 3B: Groundwater

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step 3B:** Describe the general characteristics of the groundwater basins that underlie the service area. Provide a map locating water supplier's operated wells and groundwater recharge areas, if applicable. If the water supplier operates a conjunctive use program, describe it. For managed groundwater basins, attach a copy of management plan.

### If Applicable

- ☐ Describe general characteristics of the groundwater basin(s) that underlie the water supplier (Table 21)
- ☐ Provide a map of the service area that shows the water supplier operated wells and groundwater recharge areas
- ☐ Describe conjunctive use programs
- ☐ Provide a copy of the management plan for managed groundwater basins (Table 22)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 21. District Groundwater Basins			
Basin Name	Size (Sq. Mi.)	Usable Capacity (AF)	Safe Yield (AF/Yr)

Table 22. Groundwater Management Plan	
Written By	
Year	
Is Appendix Attached?	

## Step 3C: Other Water Supplies

### MOU Guideline

Intent: To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

Step 3C: Identify any long-term water supplies not described above (i.e., drainage from upstream areas, transfer agreements with other entities).

### Compliance Provisions

☐ Identify any long term water supplies not described by surface or groundwater sources

**\*Complete Table 20 on Page 13**

## Step 3D: Source Water Quality Monitoring Practices

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step 3D:** Describe any source water quality monitoring practices currently conducted for surface water and groundwater to determine water quality problem(s) that limit use of source for water supplier's purposes.

### Compliance Provisions

☐ Describe any source water quality monitoring practices (Table 23)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 23. Water Quality Monitoring Practices		
Monitoring Location	Monitoring Practice	Monitoring Frequency

## Step 3E: Water Uses in Service Area

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step 3E:** Describe water uses within water supplier's service area supported by the water supplier's water supplies (agricultural, environment, recreational, municipal and industrial, groundwater recharge, exchanges and transfers, and other uses).

**Step 3E1:** Tabulate the type and acreage of crops grown in the water supplier's service area, evapotranspiration rate for each crop, cultural practices, and the leaching requirement to maintain the salt balance in the soil profile. This data will be used in that section on "Water Accounting."

### Compliance Provisions

- ☐ Describe a process and time table for obtaining relevant information (Table 24)
- ☐ Provide a description of types of crops grown within the service area (Table 25)
- ☐ Quantify the amount of acreage for each crop (Table 25)
- ☐ Quantify the evapotranspiration rates for each crop (Table 25)
- ☐ Provide a description of the cultural practices used (Table 25)
- ☐ Quantify the leaching requirement for crops (Table 25)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

The representative year should be used for the remainder of Step 3.

Table 24: Representative Year	
	Information
Representative year(s) based upon	
First month of representative year	
Last month of representative year	

### Step 3E: Water Uses in Service Area

#### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

#### Representative Year

Representative year defined in Table 24.

Table 25. Agricultural Crop Data							
Crop	Total Acreage	Planting Month	Harvest Month	ETcrop (AF/Ac)	Cultural Practices (AF/Ac)	Leaching Requirement (AF/Ac)	Total Crop Water Needs
<b>TOTAL</b>							

Table 26. Irrigated Acres	
Total Irrigated Acres	

Table 27. Multiple Crop Information	
Cropped Acres	
Inter-cropping	
Double Cropping	

## Step 3E: Water Uses in Service Area

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step 3E:** Describe water uses within water supplier's service area supported by the water supplier's water supplies (agricultural, environment, recreational, municipal and industrial, groundwater recharge, exchanges and transfers, and other uses).

**Steps:** Describe, if any, environmental resources supported by the water supplier's water supplies (i.e. wetlands, vernal pools, streams, wildlife refuges), and the amount of water supplied by the water supplier for these uses. Describe, if any, the type of water-related recreational facilities within the water supplier's service area which are supported by the water supplier's water supplies, and the amount of water required to maintain these facilities. Describe, if any, the municipal and industrial water use. Describe, if any, the amount of water used for groundwater recharge, including the method of recharge. Describe, if any, the amount of water that is transferred and/or exchanged into or out of the water supplier's service area, and for what uses. Describe any other significant water transactions, such as trades, wheeling, etc. Describe any other uses of water.

### If Applicable

- ☐ Provide a description of environmental resources supported by supplier's water sources (Table 28)
- ☐ Quantify amount of water supplied to environmental resources (Table 28)
- ☐ Provide a description of water-related recreational facilities supported by supplier's water sources (Table 29)
- ☐ Quantify amount of water required to maintain recreational facilities (Table 29)
- ☐ Provide a description of municipal and industrial water use (Table 38)
- ☐ Provide a description of the amount of water used for groundwater recharge, including the method of recharge (Table 30)
- ☐ Quantify the amount of water used for groundwater recharge (Table 36)
- ☐ Provide a description of the uses of water transferred or exchanged into or out of service area (Table 31)
- ☐ Quantify the amount of water transferred or exchanged into or out of the service area (Table 31)
- ☐ Provide a description of any other uses of water (Table 38)

**Step 3E: Water Uses in Service Area (continued)****Example Format**

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

**Representative Year**

Representative year defined in Table 24.

Table 28. Environmental Water Uses	
Environmental Resources	Volume (AF)
Vernal pools	
Streams	
Other	
<b>Total</b>	

Table 29. Recreational Water Uses	
Recreational Facility	Volume (AF)
<b>Total</b>	

Table 30. Groundwater Recharge	
Recharge Volume (AF)	Method of Recharge

Table 31. Transfers and Exchanges			
From What Agency	To What Agency	Type (Ag to M&I, M&I to Ag, or Ag to Ag)	Volume (AF)

## Step 3F: Drainage from the Water Supplier Service Area

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step F:** Identify where surface and subsurface drainage goes. If drainage leaves the service area and is reused, identify the discharge location and quantity. Describe any water quality monitoring programs for surface or subsurface drainage water (frequency of measuring and analyses performed). Identify any measured constituents (i.e., selenium, pesticides, boron) that limit reuse of the drainage water. Describe any usage limitation resulting from the drainage water quality.

### Compliance Provisions

- ☐ Identify where surface and subsurface drainage goes (Table 32)
- ☐ Describe any water quality monitoring programs for surface and subsurface drainage water (Table 33)
- ☐ Identify measured constituents that limit the reuse of drainage water (Table 34)
- ☐ Describe any usage limitation within the service area that is a result of drainage water quality (Table 34)

### If Applicable

- ☐ Identify the discharge location of drainage that leaves the service area (Table 32)
- ☐ Quantify the amount of drainage that is reused (Table 35)

**Step 3F: Drainage (continued)****Example Format**

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

**Representative Year**

Representative year defined in Table 24.

Table 32. Drainage Discharge Locations			
Surface/Subsurface Drainage	Estimated Volume (AF)	End Use	Inside/Outside the District

Table 33. Water Quality Monitoring Programs for Surface/Sub-Surface Drainage		
Monitoring Program	Analyses Performed	Frequency of Analysis

Table 34. Drainage Reuse Impacts						
Analyte	Detected (Check)	Drainage Reuse Limitations (Check)				
		Increased Leaching	Blending Supplies	Restricted Area of Use	Restricted Crops	Other
TDS						
Se						
B						
Mo						
As						
Na						
Cl						
Pesticide						
Herbicide						
Fertilizer(NO <sub>3</sub> )						
Other						

## Step 3G: Water Accounting

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Steps:** Tabulate a water supply inventory for the water supplier based on a representative water supply year. Identify the basis used to develop the water supplier's representative water supply year. Quantify all surface water supplies, imported to or originating within the water supplier's service area, by month, groundwater extracted by the water supplier, by month, the effective precipitation, annually, the estimated groundwater extracted by non-water supplier parties within water supplier's boundaries (if records are not available, provide an estimate and basis for estimation), the amount of recycled water, and other water supplies.

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### Compliance Provisions

- ☐ Identify the basis used to develop the representative water supply year (Table 24)
- ☐ Quantify the amount of effective annual precipitation (Table 41)

### If Applicable

- ☐ Quantify the monthly amount of all surface water supplies imported to or originating within the service area, (Table 35)
- ☐ Quantify the monthly amount of groundwater extracted by the water supplier (Table 36)
- ☐ Quantify the amount of groundwater extracted by non-water supplier parties within the service area (Table 36)
- ☐ Quantify the amount of recycled water (Table 35)
- ☐ Quantify other water supplies (Table 35)



### Step 3G: Water Accounting – Supplies (Continued)

#### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

#### Representative Year

Representative year defined in Table 24.

Table 36. Groundwater Supplies Summary (AF)							
Month	Pumped by the Water Supplier			Pumped within Service Area by Customers			Total
	Basin 1	Basin 2	Basin 3	Basin 1	Basin 2	Basin 3	
January							
February							
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							
<b>Total</b>							

## Step 3G: Water Accounting - Uses

### MOU Guideline

- Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.
- Steps:** Tabulate the following water uses: applied water, consumptive use by crop evapotranspiration and riparian
- 3G2a-n** vegetation, seepage, evaporation, operational spills, leaching and cultural practices, municipal and industrial, environmental purposes, recreational purposes, groundwater recharge, conjunctive use, water exchange, water transfers, estimated deep percolation, flows to saline sink, flows to perched water table, total recycled water, water leaving the water supplier's service area, and other. Using the water supply and water use data tabulated above, prepare a water budget summary that quantifies to the best of your ability: (1) water supply delivered into the service area (surface and groundwater), (2) crop water use, (3) environmental water use, (4) other beneficial water uses (leaching, cultural practices, M&I, recreation, recharge, etc.), (5) evaporative and consumptive riparian vegetation losses, (6) recoverable and nonrecoverable percolation losses, and (7) recoverable and nonrecoverable surface and subsurface outflows. Discuss the need for firmness of supply based upon factors of importance to the water supplier.

### Compliance Provisions

- ☐ Quantify total applied water (Table 37)
- ☐ Quantify total consumptive use of evapotranspiration (Table 38)
- ☐ Quantify total consumptive use of riparian vegetation (Table 38)
- ☐ Quantify total seepage, evaporation, and operational spills (Table 38)
- ☐ Quantify total water use for leaching and cultural practices (Table 38)
- ☐ Quantify total groundwater recharge (Table 38)
- ☐ Quantify total conjunctive use (Table 38)
- ☐ Quantify total water exchanges or transfers out of district (Table 38) and into district (Table 41)
- ☐ Quantify total estimated deep percolation (Table 42)
- ☐ Quantify total other water uses (Table 38)

### If Applicable

- ☐ Quantify total amount of municipal and industrial water use (Table 38)
- ☐ Quantify total water use for environmental and/or recreational purposes (Table 38)
- ☐ Quantify total flows to saline sink or perched water table (Table 40)
- ☐ Quantify total recycled water (Table 41)
- ☐ Quantify total water leaving the service area (Table 39)

## Step 3: Water Accounting – Uses (Continued)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

**Representative Year**

Representative year defined in Table 24.

<b>Table 37.</b>	
<b>Applied Water</b>	
	<b>Volume (AF)</b>
Applied Water	

<b>Table 38.</b>	
<b>Quantify Water Use</b>	
<b>Water Use</b>	<b>Volume (AF)</b>
<b>Crop Water Use</b>	
1 Crop Evapotranspiration	
2 Leaching	
3 Cultural practices	
<b>Conveyance &amp; Storage System</b>	
4 Conveyance seepage	
5 Conveyance evaporation	
6 Conveyance operational spills	
7 Reservoir evaporation	
8 Reservoir seepage	
<b>Environmental Use (consumptive)</b>	
9 Environmental use - wetlands	
10 Environmental use - wildlife	
11 Riparian vegetation	
12 Recreational use	
<b>Municipal and Industrial</b>	
13 Municipal and Industrial	
<b>Outside the District</b>	
14 Transfers or Exchanges out of district	
<b>Conjunctive Use</b>	
15 Ground water recharge	
<b>Other</b>	
<b>Subtotal</b>	

<b>Table 39.</b>	
<b>Quantify Water Leaving the District</b>	
	<b>Volume (AF)</b>
1 Surface drain water leaving district	
2 Subsurface drain water leaving district	
<b>Subtotal</b>	

Table 40. Irrecoverable Water Losses	
	Volume (AF)
Flows to saline sink	
Flows to perched water table	

## Step 3G: Water Accounting – Water Budget

### MOU Guideline

**Intent:** To describe the quantity and quality of water resources (sources, uses, return flows, and drainage) of the water supplier in order to form a basis for evaluating improvements by and within the water supplier. Items for evaluation are quantity and quality descriptions of the water supplier's surface water supply, groundwater supply, other water supplies, source water quality monitoring programs, water uses within the water supplier's service area, drainage from the water supplier's service area, and a water budget. In certain circumstances, specific information may not be available. The WMP should describe a process and time table for obtaining relevant information.

**Step 3G3:** Using the water supply and water use data tabulated above, prepare a water budget summary that quantifies to the best of your ability: (1) water supply delivered into the service area (surface and groundwater), (2) crop water use, (3) environmental water use, (4) other beneficial water uses (leaching, cultural practices, M&I, recreation, recharge, etc.), (5) evaporative and consumptive riparian vegetation losses, (6) recoverable and nonrecoverable percolation losses, and (7) recoverable and nonrecoverable surface and subsurface outflows. Discuss the need for firmness of supply based upon factors of importance to the water supplier.

### Compliance Provisions

- ☐ Water supply delivered into the service area (surface and groundwater) (Table 41)
- ☐ Crop water use (Table 38)
- ☐ Environmental water use (Table 38)
- ☐ Other beneficial water uses (leaching, cultural practices, M&I, recreation, recharge, etc.) (Tables 38)
- ☐ Evaporative and consumptive riparian vegetation losses (Table 38)
- ☐ Recoverable and nonrecoverable percolation losses (Table 38 & 39)
- ☐ Recoverable and nonrecoverable surface and subsurface outflows (Table 39)
- ☐ Describe the firmness of water supply

**Step 3G: Water Accounting – Water Budget (Continued)****Example Format**

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

**Representative Year**

Representative year defined in Table 24.

<b>Table 41. Quantify Water Supplies</b>	
<b>Water Supplies</b>	<b>Volume (AF)</b>
1 Surface Water (summary total from Table 35)	
2 Groundwater (summary total from Table 36)	
3 Annual Effective Precipitation	
4 Water purchases	
<b>Subtotal</b>	

<b>Table 42. Budget Summary</b>	
<b>Water Accounting</b>	<b>Volume (AF)</b>
1 Subtotal of Water Supplies (Table 41)	
2 Subtotal of Water Uses (Table 38)	
3 Surface Drain Water Leaving District (Table 39)	
<b>Excess Deep Percolation</b>	

## Step 4: Review Previous Water Management Activities

### MOU Guideline

Intent: To allow recognition of past and current water supplier activities toward further improving water management. A water supplier shall do the following:

Step 4A: List previously implemented water management practices or Efficient Water Management Practices and identifiable results.

Step 4B: Describe current Efficient Water Management Practice implementation efforts and summarize expected results.

### Compliance Provisions

- ☐ List previously implemented water management or efficient water management practices
- ☐ Provide a description of identifiable results (Table 43)
- ☐ Provide a description of current Efficient Water Management Practice efforts (Table 43)
- ☐ Summarize expected results of the efforts (Table 43)

### Example Format

While a text description is acceptable, the use of a table is an option for providing the requested information when feasible. Example table formats are provided.

Table 43. Current Efficient Water Management Efforts							
Efficient Water Management Practices	Less Applied Water (AF)	Results (Check results that were experienced)					
		Better Water Qual.	Better Soil Qual.	Inc. Yield	Inc. Crop Qual	Reduce Ops Costs	Others
Water Management Plan							
Water conservation coordinator							
Customer water management service							
Improved communication and coordination							
Improve pump efficiencies							
Facilitate alternative land uses							
Facilitate use of recycled water							
Facilitate financing of capital improvements							
Facilitate voluntary water transfers							
Line or pipe ditches and canals							
Increase ordering and delivery flexibility							
Supplier spill and tailwater recovery systems							
Optimize conjunctive use							
Water Measurement							
Pricing or other incentives							

## Step 5: Identify Efficient Water Management Practices

### MOU Guideline

Intent: To identify EWMPs that will accomplish improved (more efficient) water management.

Step 5: EWMPs are categorized into three groups: (1) those that are generally applicable (Exhibit A, List A), (2) those that are conditionally applicable (Exhibit A, List B), and (3) other EWMPs (Exhibit A, List C). Generally applicable EWMPs are those that will be implemented by all signatory water suppliers unless extraordinary circumstances clearly demonstrate that a practice is inappropriate for a signatory. Conditionally applicable EWMPs will be implemented when they are technically feasible, economically feasible (benefits exceed costs) and financially affordable based on local conditions, and not environmentally/socially unacceptable. The WMP will document the details on why implementation of any singular EWMP is not justified.

### Compliance Provisions

Complete the appropriate Net Benefit Analysis worksheet for each of the EWMPs

#### Generally Applicable EWMPs

- ☐ Prepare and adopt a Water Management Plan (Provide proof in Step 7)
- ☐ Designate a water conservation coordinator
- ☐ Support the availability of water management service to water users
- ☐ Where appropriate, improve communication and cooperation among water suppliers, water users, and other agencies
- ☐ Evaluate the need for changes in policies of the institutions to which the water supplier is subject
- ☐ Evaluate and improve the efficiencies of water suppliers' pumps

#### Conditionally Applicable EWMPs

- ☐ Facilitate alternative land use
- ☐ Facilitate the use of available recycled water that otherwise would not be used beneficially
- ☐ Facilitate the financing of capital improvements for on-farm irrigation systems
- ☐ Facilitate voluntary water transfers that do not unreasonably affect the water user, water supplier, the environment, or third parties
- ☐ Line or pipe ditches and canals
- ☐ Increase flexibility in water ordering by, and delivery to, the water users within operational limits
- ☐ Construct and operate water supplier spill and tailwater recovery systems
- ☐ Optimize conjunctive use of water
- ☐ Automate canal structures

#### Other EWMPs

- ☐ Develop a water measurement and water use report
- ☐ Include pricing or other incentives in the Water Management Plan

## Step 6: Develop Schedules, Budgets, and Projected Results

### MOU Guideline

Intent: To identify a schedule for program implementation, the estimated budget needed for implementation and the results expected from full implementation of the WMP.

Step 6: Items for evaluation include a description of how each practice will be carried out (proposed actions, timetables, budgets, staffing needs), and projected results from full implementation of the practice(s) (i.e., changes in water use, energy usage, chemical inputs, improved yields). Whenever possible, quantify the projected results. It is understood that projected results are estimates based on best available data and are subject to change, and that the results of some EWMPs can never be quantified.

### Compliance Provisions

- ☐ Provide a description of proposed actions
- ☐ Provide a description of timetables
- ☐ Provide a description of budgets
- ☐ Provide a description of staffing needs
- ☐ Provide a description of the projected results from full implementation of each EWMP

## Step 7: Review, Evaluate, and Adopt the Water Management Plan

### MOU Guideline

Intent: To identify the process whereby the WMP is developed, reviewed, and adopted by the water supplier's governing board.

Step 7: Signatory water suppliers will develop a WMP that provides the information necessary to implement justified EWMPs. The WMP and updates shall be formally adopted by the water supplier's governing board after public review and comment. The adopted WMP will be considered a business plan which identifies opportunities to improve water management. It is expected that justified EWMPs will be implemented as part of prudent resource management.

### Compliance Provisions

- ☐ Provide proof of formal adoption of the Water Management Plan

## Step 8: Implement Justified Efficient Water Management Practices

### MOU Guideline

Intent: To take EWMPs beyond planning stage into implementation

Step 8: Because the WMP will be part of the water supplier's operations plan, implementation of justified EWMPs shall be an integral part of the water supplier's operations.

### Compliance Provisions

- ☐ Implement Efficient Water Management Practices that are justified in accordance with Step 5.

## Step 9: Monitor, Evaluate, and Update the Water Management Plan

### MOU Guideline

Intent: To ensure implementation of justified EWMPs, to monitor and evaluate the success of justified EWMPs, to allow for modification and/or revision to the scheduled implementation of the justified EWMPs, and to identify any constraints to the EWMPs.

Step 9: The status and implementation of each EWMP will be monitored, evaluated, and updated, as required, by the water supplier in the Progress Report.

**Attachment 12**

**Improving Surface Irrigation Designs and  
Management Practices in the Imperial Valley  
Wynn R. Walker**



# IMPROVING SURFACE IRRIGATION DESIGNS AND MANAGEMENT PRACTICES IN THE IMPERIAL VALLEY, CALIFORNIA

Prepared By

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Consultant

## ANTECEDENTS

In 2002 Natural Resources Consulting Engineers, Inc. (NRCE) presented an assessment of Imperial Irrigation District's (IID) reasonable and beneficial use of water. The analysis was supported by ten evaluations of fields served by IID<sup>2</sup>. The evaluations employed a standard methodology designed to produce estimates of irrigation efficiency and uniformity<sup>3</sup>. This methodology is used to evaluate the effectiveness of existing irrigation practices as well as in estimating the potential efficiencies and uniformities which result from improvements in the field design and water management practices. The NRCE report contains a summary of the evaluation data and an estimate of existing irrigation efficiencies, but it does not consider changes in either design or management that would increase efficiencies or uniformities.

In November 2002, the writer began a review NRCE field evaluation data, as well as other data being collected from farms in the IID service area, to extend the NRCE analyses to estimates of potential irrigation efficiency and uniformity. This report summarizes a series of computations using a surface irrigation simulation, evaluation, and design software package abbreviated as *SIRMOD III*.

## METHODOLOGY AND SCOPE

The *SIRMOD III* program is based on generally published procedures and algorithms for simulation, design, and evaluation of surface irrigations systems. It is a comprehensive software package for simulating the hydraulics of surface irrigation systems at the field level, selecting a combination of sizing and operational parameters that maximize application efficiency and a two-point solution of the "inverse" problem allowing the computation of infiltration parameters from the input of advance data. The software was used to evaluate the potential efficiency and uniformity of selected fields in the IID service area that NRCE has evaluated. The analysis presented herein involved the following steps:

1. A "reconstruction" of the data was made for the ten field evaluations presented in the NRCE report. The NRCE report presents a summary of most but not all results of their analyses. In order to evaluate the impact of improved design or water management practices, it was first necessary to calibrate *SIRMOD III* to the average data presented by NRCE. The results of this reconstruction allow software to simulate the irrigations of a field typical of those studied by NRCE.
2. Following calibration of the simulation portion of the software, a series of redesigned field options were evaluated to determine the extent of improvements that might be

<sup>1</sup> Utah Registration No. 152758-2202.

<sup>2</sup> Natural Resources Consulting Engineers, Inc. 2002. Assessment of Imperial Irrigation District's Water Use. Report and Appendices. March.

<sup>3</sup> Merriam, J.L. AND Keller, J. *Farm irrigation system evaluation: A guide for management*. 1978. Department of Biological and Irrigation Engineering, 4105 Old Main Hill, Logan, Utah, 84322-4105

<sup>4</sup> Walker, W. R. 2003. "*SIRMOD III* - Surface Irrigation Simulation, Evaluation, and Design, Guide and Technical Documentation. Biological and Irrigation Engineering. Utah State University, Logan, Utah. 146p.

- possible in both uniformity and efficiency. Each redesign was evaluated with revised water management practices in order to optimize the use of water on the field.
3. A comparison of existing field performance as measured by NRCE and projected performance estimated by the software was used to estimate water savings possible through redesign of the existing systems.
  4. The performances of the on-farm components of the irrigation system are sensitive to the management of the IID delivery network. A single analysis was made to illustrate the problem of delivery management on the efficiency and uniformity of the farm irrigation system.
  5. The spatial distribution of leaching fractions was examined for nine of the ten NRCE field sites under measured and redesigned conditions.
  6. An analysis of one additional field evaluation conducted by Payne for MWD was conducted with the software to extend the conclusions of the writer somewhat beyond the scope of the NRCE analyses.

Nine of the ten field evaluations reported by NRCE involved graded borders which are used locally to irrigate alfalfa, Sudan and Bermuda grass, etc. One field was furrow irrigated (Field 8) but was growing alfalfa at the time of the study. These conditions are estimated to represent about 50% of the irrigated area in the IID system. All of the evaluations were preceded by earlier watering and thus represent a mid-season condition for the fields studied. The Field 10 irrigation was being used for a special leaching application and has not been examined beyond the initial calibration. The data collected by Payne represented the case of a different soil being irrigated earlier in the season.

### TECHNICAL NOTES

In describing the infiltration characteristics of the fields evaluated, NRCE notes the dependence of intake rate on initial soil moisture and surface cracking. They subsequently assign a portion of the water added to the crop root zone to the cracks. Expressed in this fashion, the cracks would act similar to depression storage on the field surface. However, the cracks vanish during the irrigation as the soils swell, and thus, whatever initial volume of water is needed to fill the cracks during the advance of water over the field is likely "given back" when the cracks close. A more likely consequence of the cracks is they substantially increase the contact area of the field for a short period during the irrigation, and thus, most of the water added to the root zone via cracks is due to normal infiltration processes within a temporarily increased contact area. The results of the calibration analyses indicate that special considerations of soil cracking in terms of depression storage are not necessary.

NRCE also presents their estimates of the "intake rate after initial infiltration (in/hr)". The values presented are more typical of silty loam soils rather than the clay and clay loam soils encountered in the fields evaluated.

NRCE appeared to state that measurements of surface storage during the advance allowed them to estimate the soil intake characteristics, but none of this information was reported. Consequently this work is based on simulations made using the NRCE data on advance times, set times, tailwater volumes, and root zone storage depths to establish conditions of a similar nature to those reported.

### CALIBRATION RESULTS

Results of the ten *SIRMOD III* calibrations are presented in Table 1 alongside NRCE reported results.

TABLE 1. COMPARISON OF *SIRMOD III* AND NRCE EVALUATIONS FOR TEN IIR FIELD SYSTEMS

1	258- 276	304	28	27	68	70	3	3	72	73	97
2	216- 240	238	14	14	84	83	3	3	87	86	92
3	720	735	13	13	82	82	5	5	87	86	89
4	258- 318	315	0	0	80	80	20	20	85	86	74
5	2010- 2100	1880	6	6	78	77	17	17	87	83	85
6	408- 444	486	12	13	80	79	9	8	88	85	94
7	474- 480	495	19	19	76	76	5	5	80	80	92
8	180- 210	169	20	20	76	75	5	5	80	79	93
9	570- 600	490	20	21	78	76	3	3	80	79	97
10	3 days	22.5 hrs	0	2	48	56	37	41	N/A	61	99

<sup>6</sup> Root Zone Storage is the same as the term "application efficiency" used in irrigation literature.

<sup>7</sup> NRCE Irrigation Efficiency is the Root Zone Storage percentage plus a 2% - 8% value for leaching fraction. How the leaching fraction was determined is unclear.

<sup>8</sup> The *SIRMOD III* software estimate of irrigation efficiency is the root zone storage plus up to 8.5% leaching fraction as suggested by Rhoades and divided by the total applied water to the field, including tailwater. The uniformity of leaching is such that even though an average leaching fraction on a field might average 8.5%, some areas might receive more, resulting in excessive deep percolation, and the actual leaching fraction added to the root zone storage would be less.

## ANALYSES OF SELECTED ON-FARM WATER MANAGEMENT IMPROVEMENTS

Flows from the irrigated fields of the IID service area are comprised of tailwater and drainage (a component of which is tilewater). About one-half of the local soils have low infiltration characteristics, and thus given the need for leaching of salts, the opportunities for water management and conservation necessarily emphasize tailwater controls. The NRCE report estimates that field tailwater in the IID service area averaged 17% of headgate diversions during the period 1988-1998. Electronic records from 285 irrigation events, which includes well managed irrigation events of <5% (excluding these events the average tailwater percentage is about 20%), during the 2001 year indicate an average tailwater percentage of about 15%. Tailwater is highly variable depending on irrigator skill, water management practices, system design, and delivery rates from the IID canal and lateral system. During 2001, for example, tailwater losses ranged from 0-55%. The average tailwater losses from the ten fields evaluated by NRCE were nearly 15% (excluding Field 10 for reasons noted above). Therefore, fairly consistent estimates of the average tailwater volume have emerged from NRCE analysis and IID monitoring.

There are three primary tailwater control strategies: (1) blocking the end of the fields to prevent runoff; (2) capturing the runoff and reusing it. (Both of these strategies are already found in the IID service area); and (3) terminate the inflow soon enough to eliminate or minimize the tailwater. The third option will generally result in inadequate watering and leaching at the lower end of the field, and while it is an alternative, it does not appear to this writer to be realistic over the long term.

The impact of widespread tailwater capture and reuse will not be detailed here beyond what is easily determined. If tailwater now occurring were collected and reused, the headgate diversions per acre could be reduced accordingly.

Diking the end of the field to prevent tailwater runoff is a common practice through the western U.S. and could be implemented in the IID service area with limited modifications to existing furrow and border irrigation systems. The IID monitoring in 2001 shows that while the likelihood of field tailwater exceeding five percent of headgate diversion is 74%, about one in four fields (26%) had less than five percent tailwater. Given the importance of water in Southern California and the conflict current use practices are engendering, a question arises as to whether or not the 74% areas could be managed to achieve the 5% tailwater limitation, what the costs would be, and what impact of salt leaching could be anticipated.

In the following three sections, analyses of tailwater control and leaching will be directed toward three questions. The first is the distribution of leaching associated with the NRCE field evaluations and the view this presents concerning an overall leaching strategy. The second is what might be the impacts of end-of-field diking on water demands and leaching under a 5% tailwater control policy. And the third is an examination of attainable levels of leaching under a 5% tailwater control policy.

### Existing Leaching Distributions

Once the *SIRMOD III* software had been calibrated with the NRCE measurements, simulation of the applied water distributions in each of the nine representative field cases was made, and then given the soil moisture depletion reported by NRCE, the leaching fractions were simulated. Figures I-1 thru I-9 in Annex I show the results of these simulations.

As shown in Table 1, the average leaching fractions on the nine NRCE fields ranged from 3% to 20% while the distribution of leaching over the field lengths, shown in Figures I-1 - I-9, ranged from 0% to almost 30%. Typically, these simulated mid-season irrigations would not provide very uniform leaching over the field length, with particular problems at the inlet and/or outlet. Thus, while the uniformity of the water application is generally high, the leaching is not. One way of

increasing leaching is obviously to extend the time of irrigation but this practice would increase tailwater runoff<sup>9</sup>. Another is to irrigate slightly more frequently and apply about one-half inch less per irrigation. The important conclusion from these analyses is that even when average leaching fractions are below the threshold indicated by the salinity in the irrigation water, substantial parts of the field may be adequately leached even during mid-season irrigations. The corresponding distribution of leaching during other irrigations, particularly any pre-plant and post-plant irrigations, would be likely to be more effective in leaching near the upper and lower ends of the field. Consequently, over periods of cropping seasons and cropping rotations, the uniformity of leaching may be substantially different than indicated by simulating the NRCE evaluations.

#### Simple Blocked-End Border Irrigation

In the second analysis performed with the *SIRMOD III* software, a dike was simulated at the downstream end of the field and the inflow and times of cutoff were adjusted to achieve a 5% tailwater constraint. It was further assumed that the average leaching should be at least 5% in order to prevent excessive under-irrigation. A small 200 ft strip of the field at the lower end was simulated with an adjusted slope of 0.0005 in order to increase the intake opportunity time at the downstream end of the field. The results are tabulated in Annex II. The resulting leaching distributions are shown in comparison with the original cases in Figures II-1 thru II-9. It should be noted that diking the downstream end of the field does not completely eliminate tailwater as water may need to be released after a given length of time to prevent scalding.

Taking the NRCE fields as typical of about 50% of the IID service area and making the additional assumption that the field conditions evaluated by NRCE would represent a preponderance of irrigations on fields growing alfalfa and grass, the average cost of diking the lower end of the border and flattening the last 200 feet of the field averages about \$20 per acre. This investment would return an average of about 0.6 to 0.7 acre-feet/acre in water savings. The blocked-end control of tailwater does not mitigate the problem of uneven leaching during the mid-season irrigations, although it does move the under-leached region up the field which may have some advantage for leaching during the early season or post-cultivation irrigations. In any event, it is clear that blocking the end of a border to control tailwater within 5% of headgate diversions, based on the NRCE evaluations, would not increase either the area under-irrigated or under-leached. Thus, this alternative for mitigating a decrease in water supply of about 0.6 acre-foot/acre could be made without any impact on crop yields and only a modest investment in land leveling.

#### Field Re-Design

According the Rhoades' declaration<sup>10</sup>, the leaching requirements in the IID service area should average about 8.5%. This figure along with the assertion that tailwater could be limited to 5% of headgate diversions poses the hypothetical question as to whether or not both constraints might exist simultaneously. This question was addressed by simulating the NRCE fields 1-9 under different inflows, cutoff times, and land leveling practices. For this series of simulations, there were four constraints placed on the analysis: (1) the end of the fields were assumed to be blocked subject to a scalding protection release; (2) the fields were re-leveled to have the lowest 400-800 feet graded to 0.05%; (3) the average leaching need to be at least 8.5%; and (4) the total water use needed to be less than reported by NRCE. This last constraint was used to test whether or not water conservation would be possible by imposing tailwater constraints as upper bounds and leaching as a lower bound.

Annex III presents the results of these simulations. Table III-1 and Figures III-1 - III-9 show that for the NRCE fields both tailwater and leaching constraints can be imposed by adjusting inflow

<sup>9</sup> Tailwater would have to exist for a length of time needed to refill the crop root zone at the end of the field plus the infiltration time needed to add the incremental leaching fraction.

<sup>10</sup> Declaration of James D. Rhoades in Opposition to IID's Motion for Preliminary Injunction.

rates, set times, and by leveling the lower end of the fields. The average leaching possible with a 5% tailwater constraint is 13% and the water savings would average 0.30 af/ac, although two the fields would require slightly more water if the leaching was allowed to be as high as shown. Adjustments to the inflow time and rate as well as the field configuration to achieve both constraints could be made to lower water requirements, but it would be prudent to exceed the lower bound on leaching by 1-3% to offset the non-uniformity in leaching that is inherent in these mid-season irrigations.

The costs shown in Table III-1 are based on a \$0.75 per cubic yard of cut and hauled material. The cuts averaged 0.17 feet (2 inches). These changes will require a small investment to change the field slopes of about \$78 per acre.

Two other factors in the re-design of the fields are the sets and the design flow from the IID system. These were modified slightly but are within the range of existing practice. All set times are rounded to quarter-hourly steps for ease in scheduling and ordering water.

Pre-plant, emergence, and late season irrigations are normally less efficient than those during the midseason. Early irrigations tend to have greater deep percolation and later ones higher tailwater. Thus, the results in Annex III are conservative in the sense that higher leaching fractions may be possible over the season and certainly from crop rotation to rotation.

### **IMPLICATIONS FOR IID MANAGEMENT**

An important issue for managing water under a tailwater control strategy is the impact that management and operation of the IID canals and laterals can have on on-farm irrigation performance. A border irrigated farm could be re-designed to achieve high efficiency and uniformity but perhaps would not be operated at these levels unless the headgate deliveries would be steady and made at the proper flow.

A simple illustration can be made to address this issue. If NRCE Field 1 is redesigned to with a blocked end and a flattened slope over the lower 400 feet, it can be irrigated with three sets, each using 13.9 cfs from the IID system. The performance of the irrigation system at the farm level is shown in Table III-1, where resulting irrigations could be made at an irrigation efficiency of about 93% (including 8.5% for leaching), a distribution uniformity of 97%, and a tailwater loss of about 5%. The grower would require about 80 acre-feet less from the IID system, a savings of \$1,280 per year assuming a water charge of \$16 per af, but would incur about \$6,500 in land leveling costs plus perhaps an additional amount for lost production in the cut areas for a season or two.

If the IID system does not supply this grower with the 13.9 cfs required to optimize irrigation of the borders then the efficiencies may decrease and the costs of the improved water management would not be recovered. Suppose the actual flow rate varied between 25% less than the design flow to 25% more. If the grower is able to adjust set times to make the best use of water given the inflow discharge, the results would be similar to those summarized in Figure 1 below.

## IID Delivery Variation on Irrigation Performance

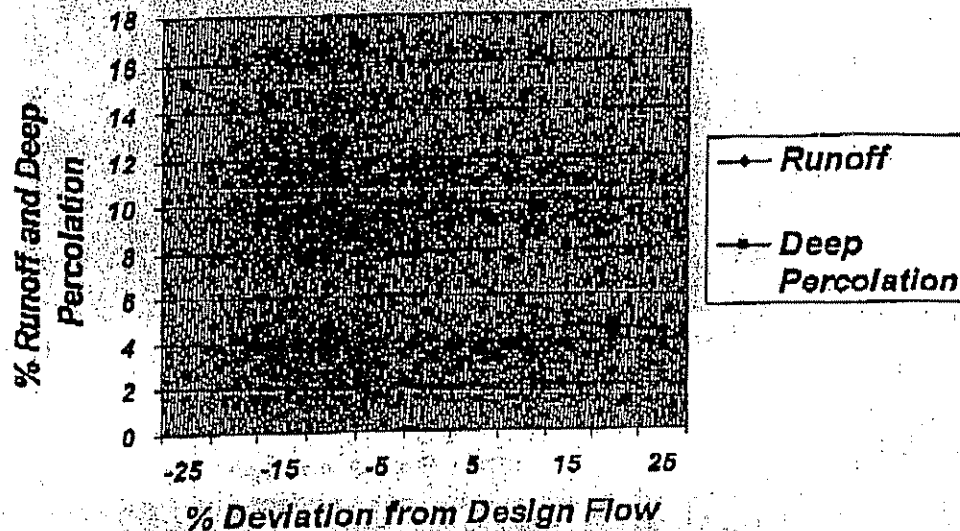


Figure 1.

When the IID deliveries fall short of the required flow, the deep percolation, and thus leaching increase proportionately. As the delivered flow increases, the opportunity for leaching decreases. Controlling tailwater to a 5% limit is possible but would require the irrigator to shutoff the inflow at different times. There may be long-term consequences of the high inflows relative to leaching on the field and certainly the water management would require more labor to increase monitoring of water advance.

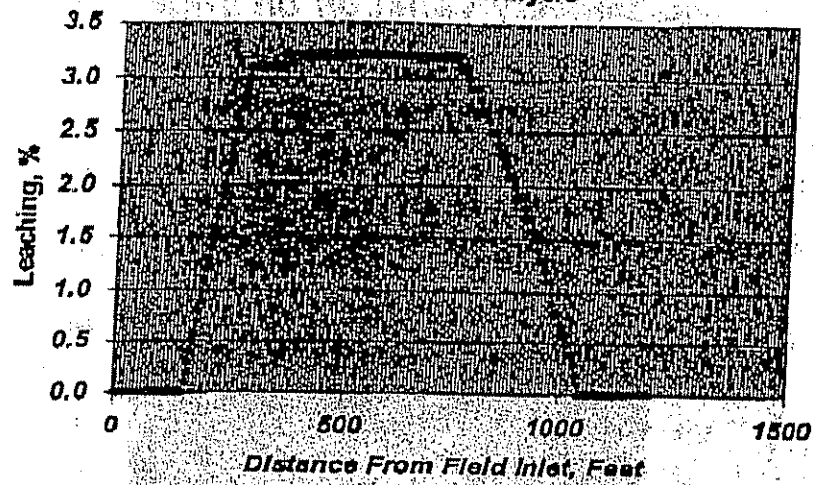
### SUMMARY

The foregoing analysis of NRCE data with the *SIRMOD III* software shows the field evaluations of the ten fields in the IID service area yielded realistic estimates of the on-field irrigation performance during mid-season irrigations of alfalfa and grass in the regions of the heavy soils. There are, however, questions regarding the validity of NRCE estimates of soil moisture depletion and soil moisture holding capacity based on three soil samples which appear to have been collected over fields as large as 70 acres. Further, not all evaluation data were presented in the report.

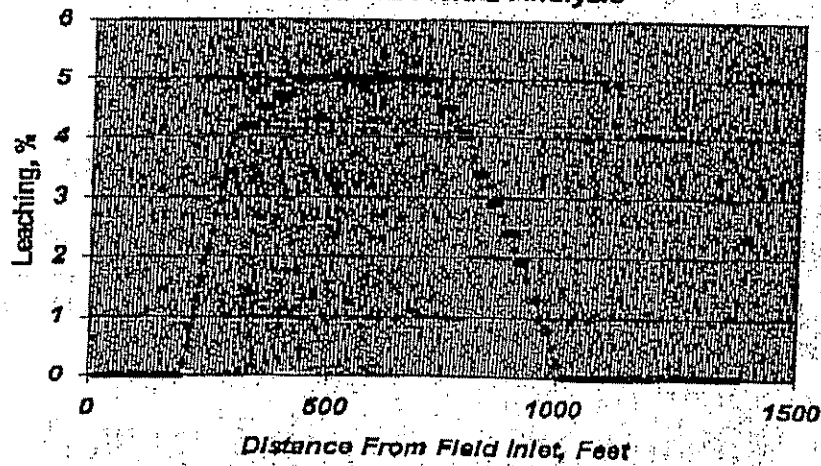
Perhaps the most serious limitations of the NRCE evaluations are: (1) the lack of pre-plant or emergence irrigations; (2) irrigations on the lighter soils; and (3) the furrow irrigation of row crops. These events are typically different than mid-season irrigations because the infiltration rates are substantially higher, the soil surface is rougher, the impedance due to crop growth is less, and the soil moisture depletions may be less.

# **ANNEX I – LEACHING DISTRIBUTIONS IMPLIED BY NRCE FIELD EVALUATIONS**

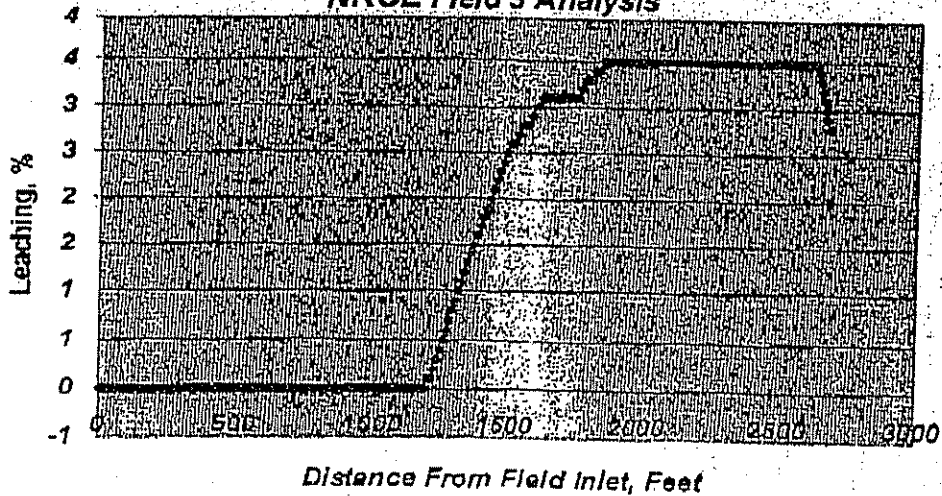
**NRCE Field 1 Analysis**



**NRCE Field 2 Analysis**



**NRCE Field 3 Analysis**



### NRCE Field 4 Analysis

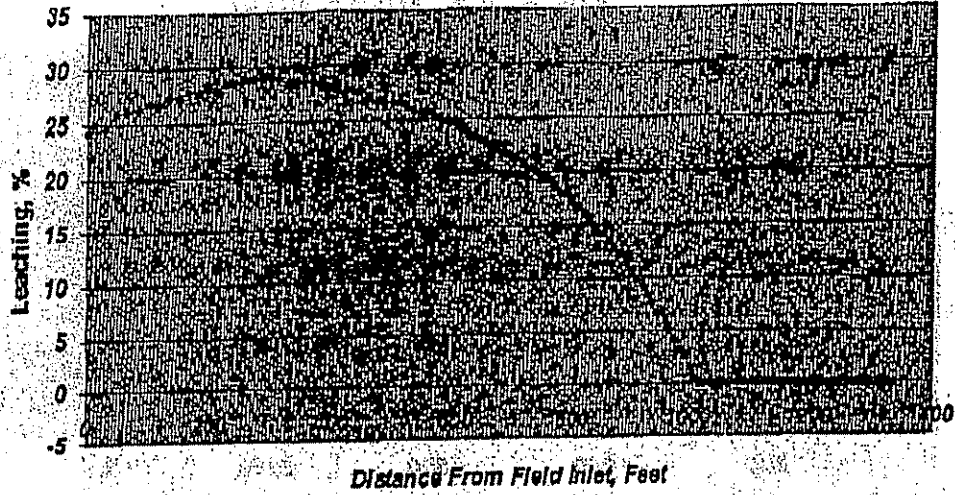
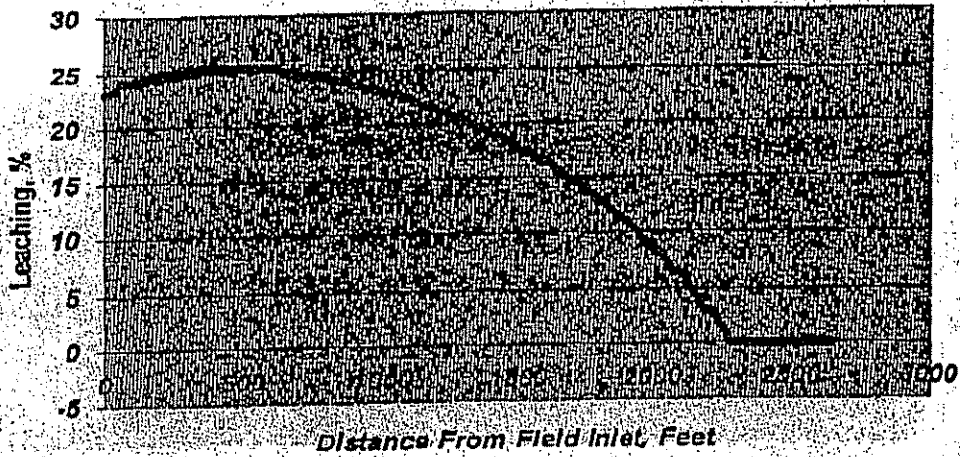
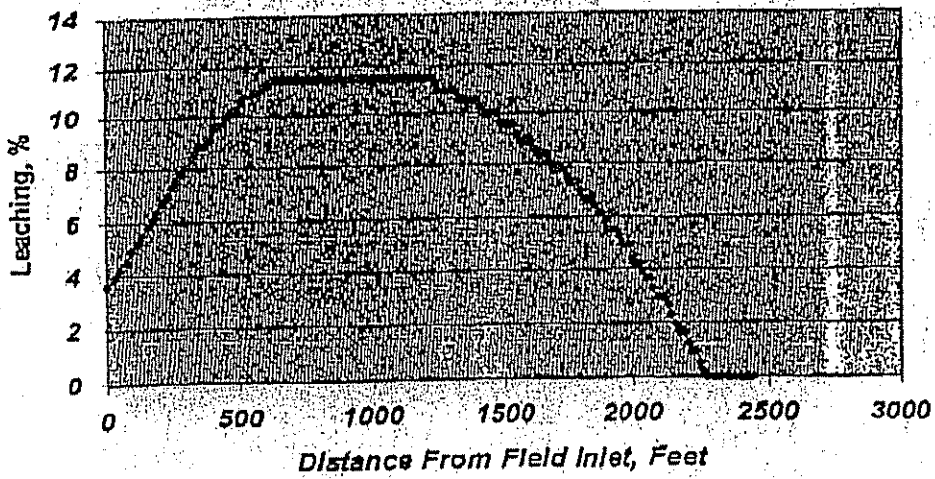


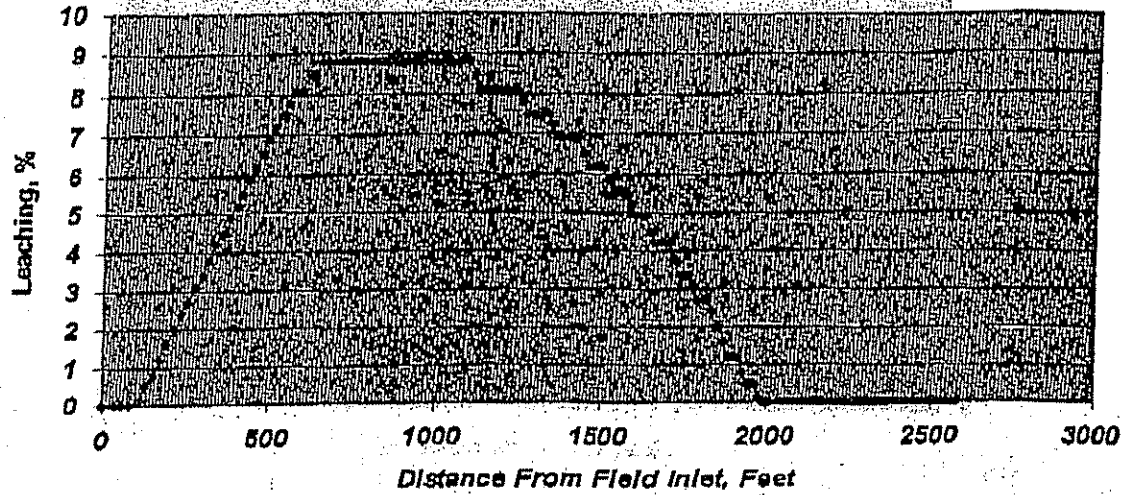
Figure II-5. NRCE Field 5



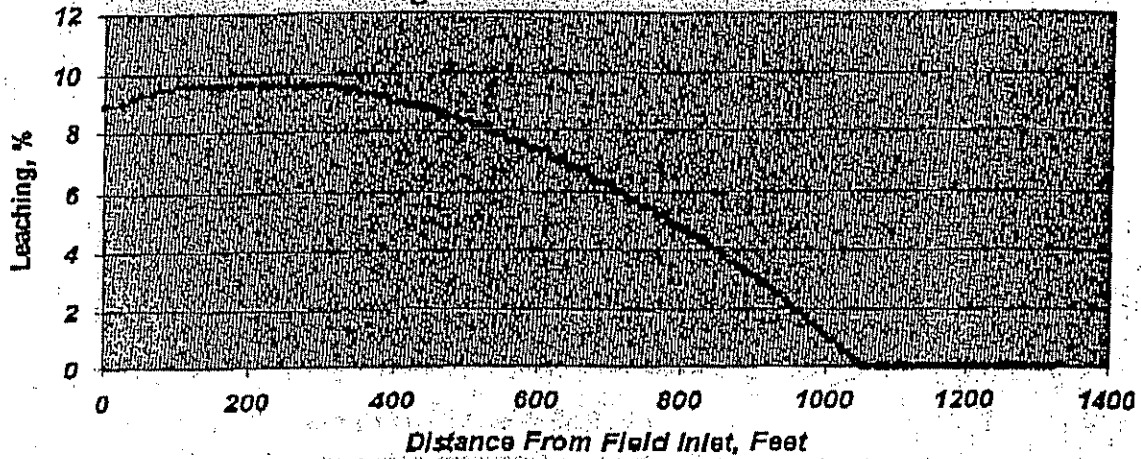
### NRCE Field 6 Analysis



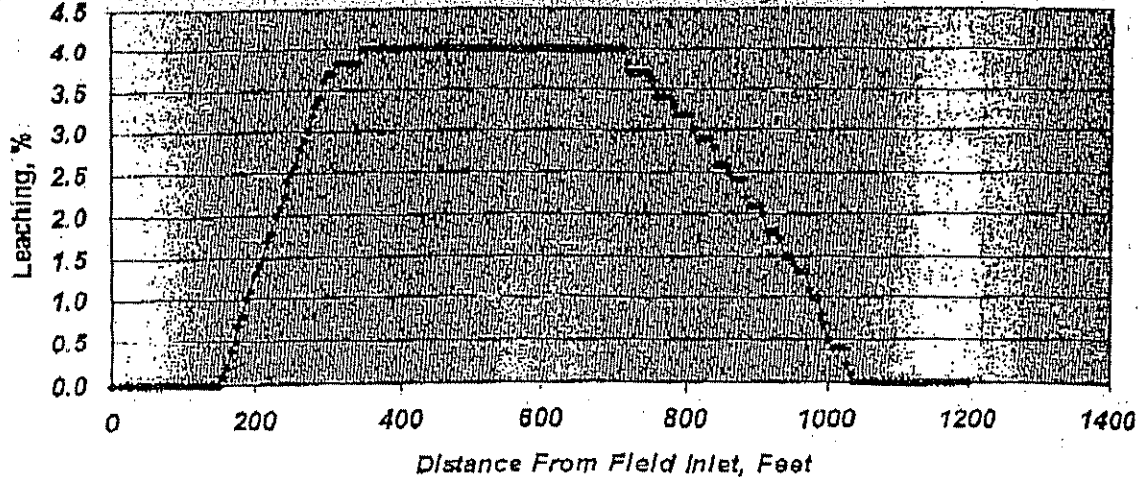
**Figure II-7. NRCE Field**



**Figure II-8. NRCE Field B**



**NRCE Field 9 Analysis**



**ANNEX II - ANALYSES OF BLOCKED-END AMENDMENTS TO WATER USE AND LEACHING IN THE NRCE EVALUATION FIELDS.**

1	2	3	4	5	6	7	8	9	10	11
1	5.5	3	3	0.017	94	95	5	6	\$29	94
2	3.0	3.5	10	0.043	92	93	4	7	\$17	24
3	4.0	3.5	10	0.061	94	94	5	6	\$20	53
4	2.75	4.0	10	0.052	92	91	4	11	\$27	35
5	17.5	3.5	2	0.0158	93	91	5	8	\$9	32
6	5.5	4.2	4	0.05	93	94	4	7	\$15	40
7	8.0	5.0	5	0.042	93	89	5	7	\$16	87
8	3.0	3.0	8	0.115	94	94	5	7	\$26	52
9	13.0	3.0	4	0.0072	93	93	5	6	\$14	40

Figure II-1. NRCE Field 1

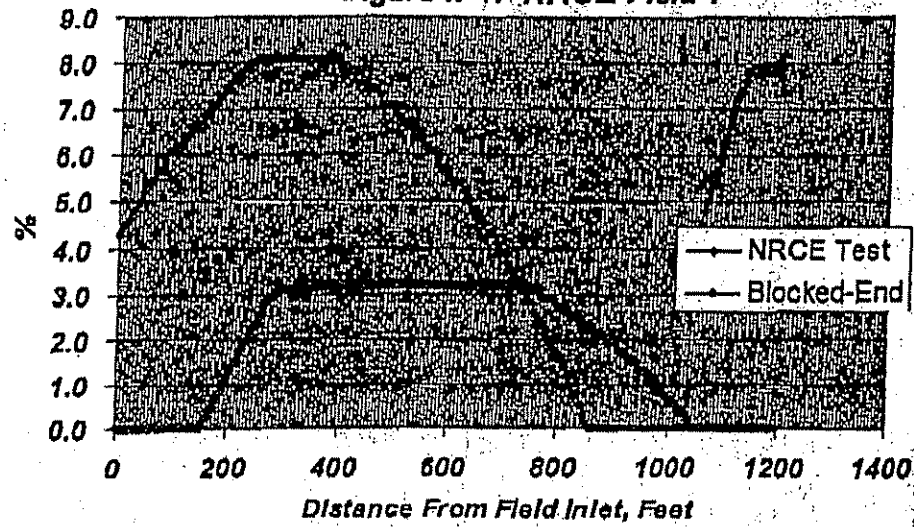


Figure II-2. NRCE Field 2

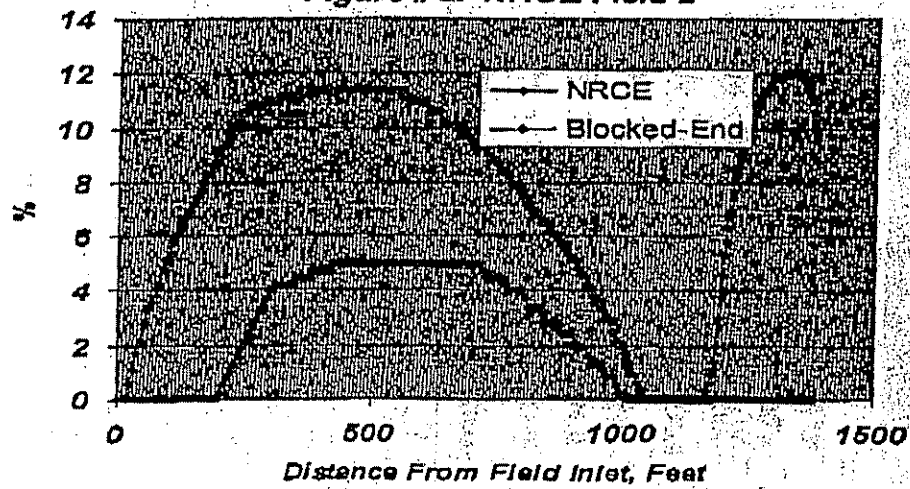


Figure II-3. NRCE Field 3

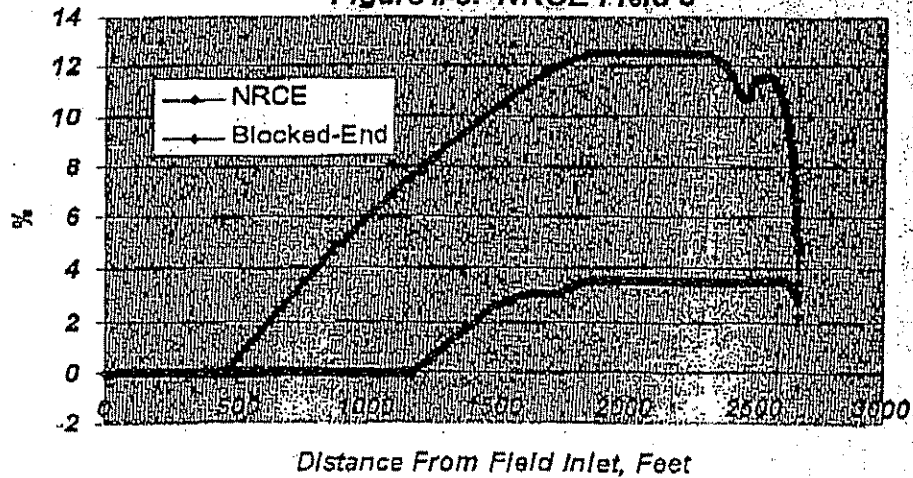


Figure II-4. NRCE Field 4

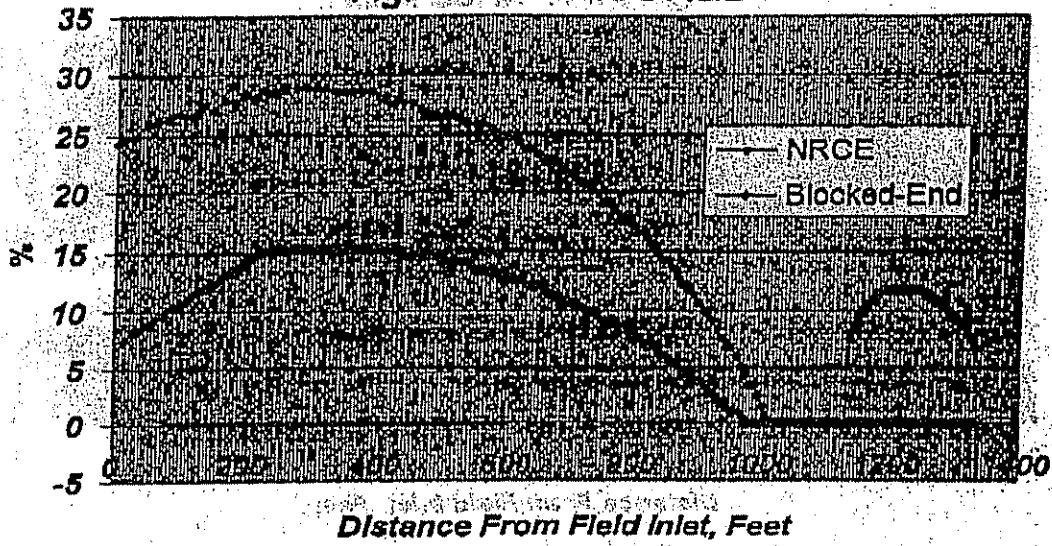


Figure II-5. NRCE Field 5

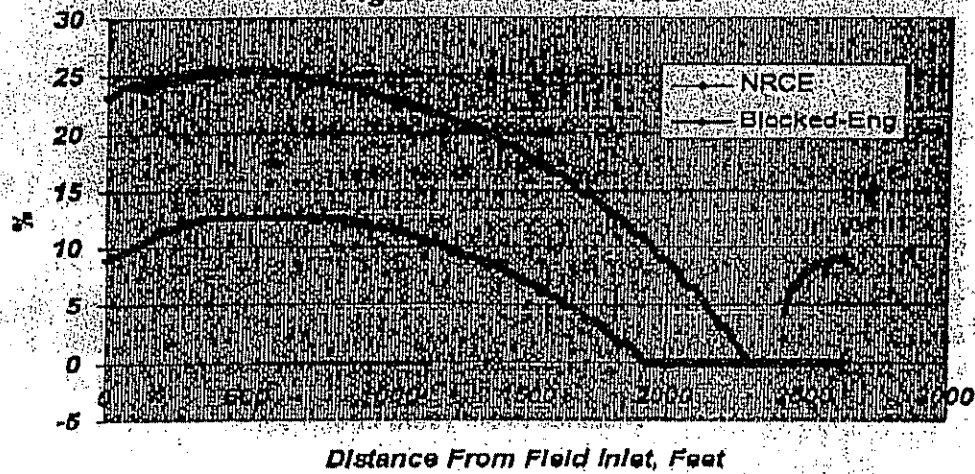
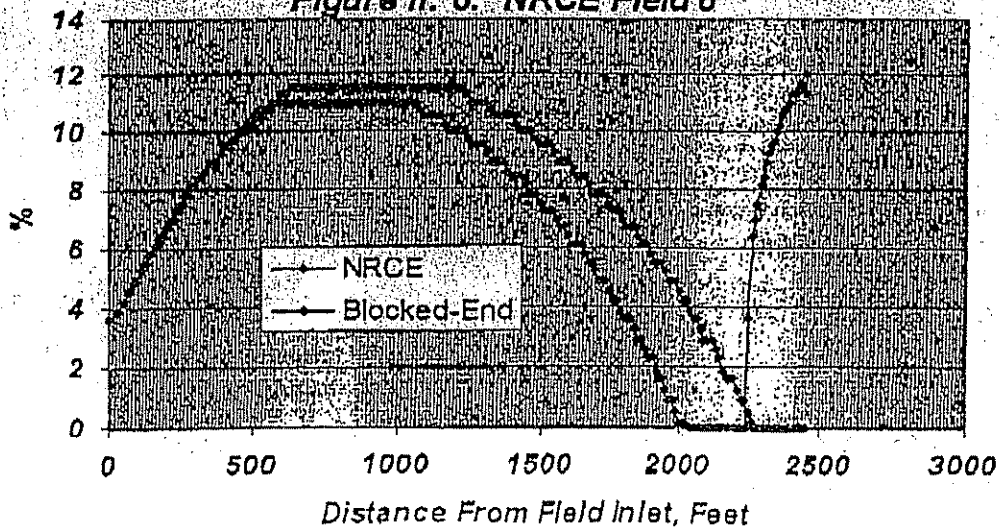
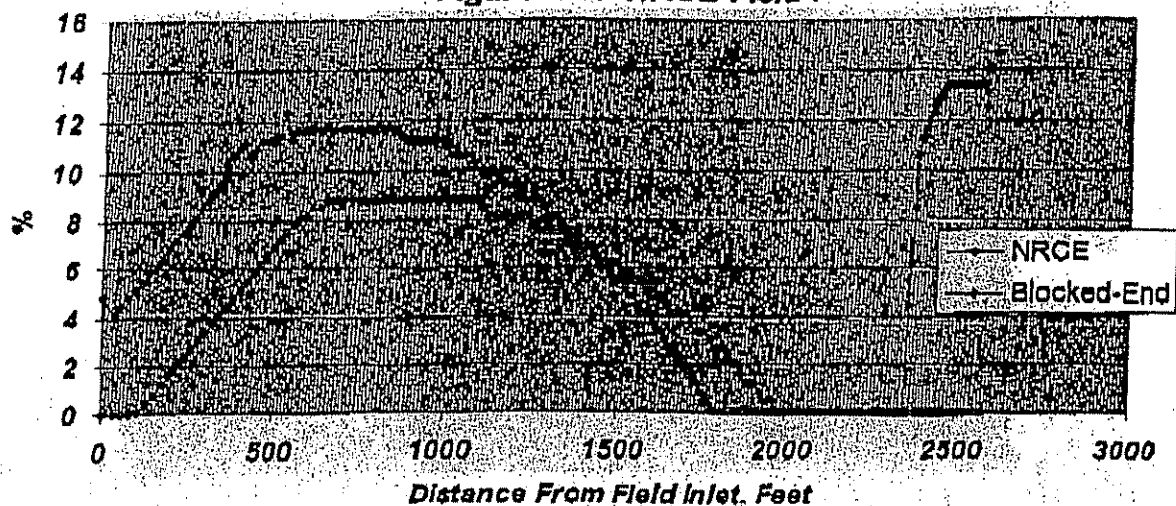


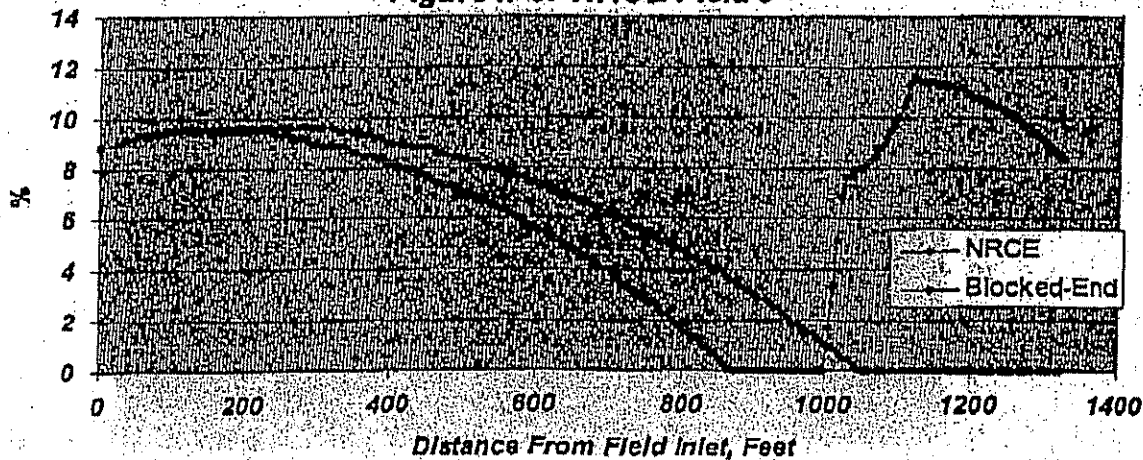
Figure II. 6. NRCE Field 6



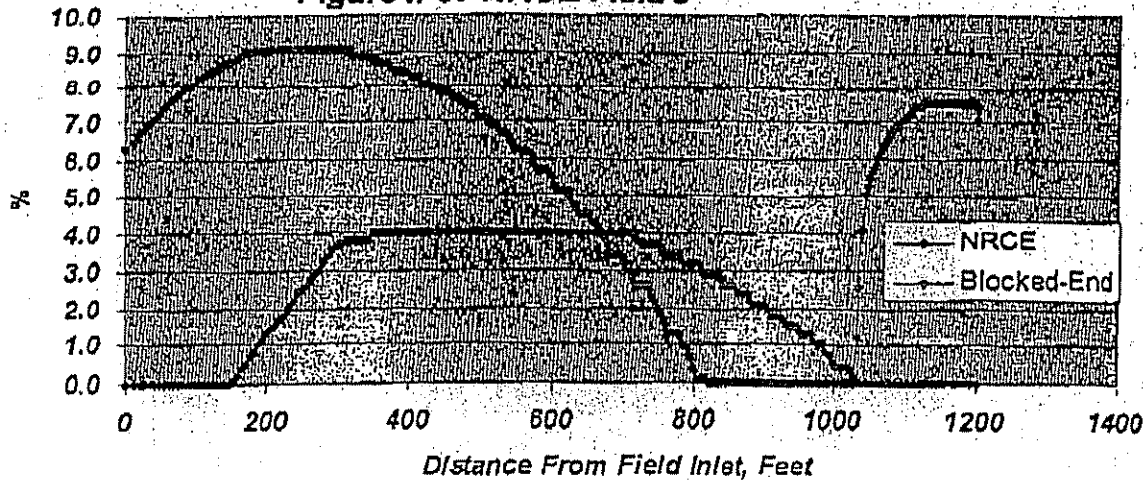
**Figure II-7. NRCE Field 7**



**Figure II-8. NRCE Field 8**



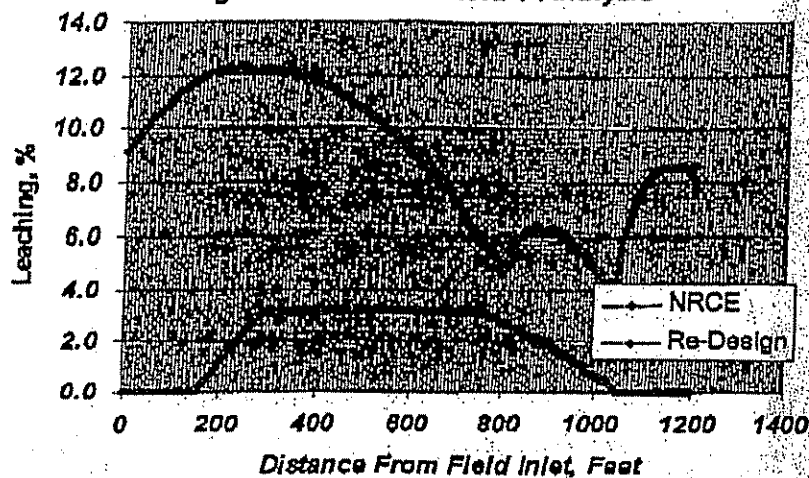
**Figure II-9. NRCE Field 9**



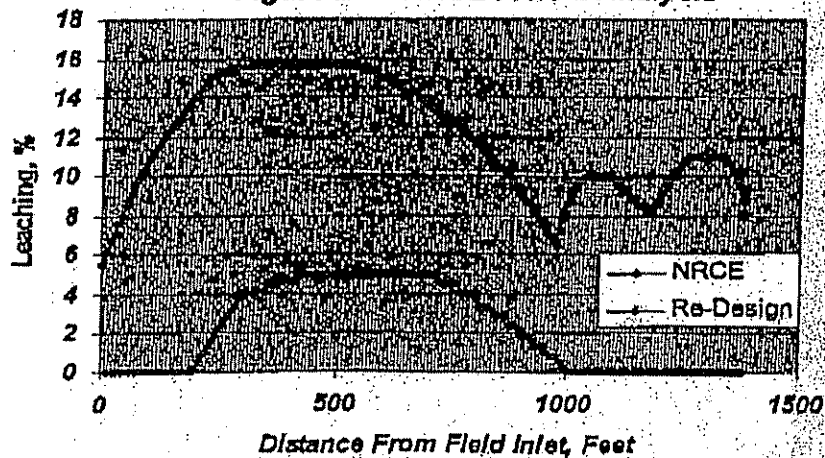
**ANNEX III – ANALYSES OF RE-DESIGNED BLOCKED-END BORDER PERFORMANCE IN THE NRCE EVALUATION FIELDS.**

Field	Design	Block	Slope	93	97	5	10	Cost	79
1	Change slope of the last 400 feet to 0.0005, block end, and adjust unit flow	3	0.016	93	97	5	10	\$6,500	79
2	" "	3.5	0.039	89	96	5	13	\$4,200	-11
3	" "	3.5	0.0326	91	98	5	12	\$10,800	9
4	" "	4.0	0.05	89	94	3	15	\$6,200	12
5	Change slope of the last 880 feet to 0.0005, block end, and adjust unit flow	3.5	0.01925	90	96	5	13	\$8,700	15
6	Change slope of the last 400 feet to 0.0005, block end, and adjust unit flow	4.0	0.044	87	94	5	16	\$4,000	-5
7	Change slope of the last 700 feet to 0.0005, block end, and adjust unit flow	5	.0403	90	94	5	13	\$10,200	47
8	Change slope of the last 300 feet to 0.0005, block end, and adjust unit flow	5	0.093	90	96	5	13	\$3,700	28
9	Change slope of the last 400 feet to 0.0005, block end, and adjust unit flow	2.5	9.4	91	98	5	12	\$3,500	21

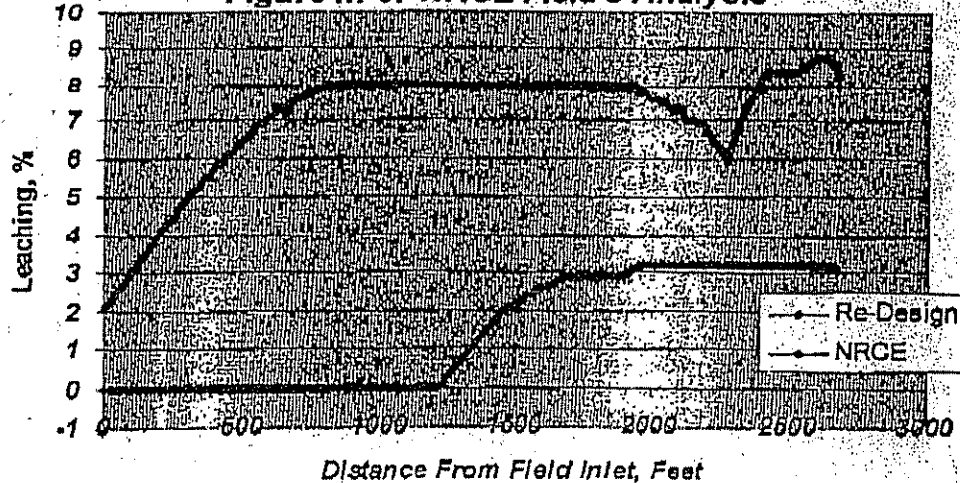
**Figure III-1. NRCE Field 1 Analysis**



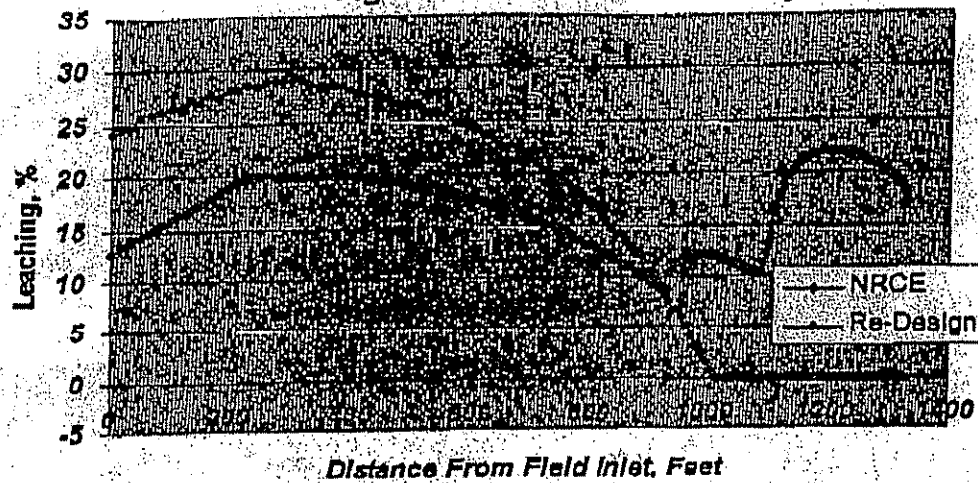
**Figure III-2. NRCE Field 2 Analysis**



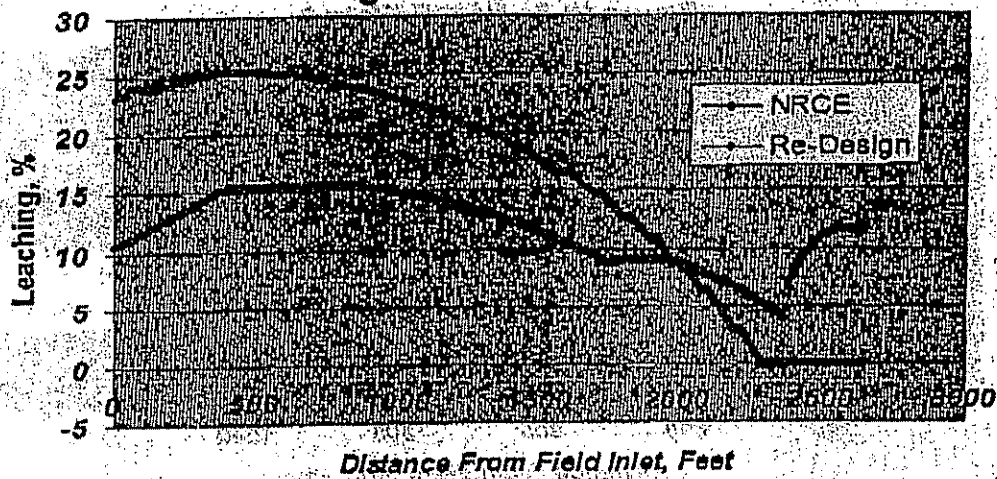
**Figure III-3. NRCE Field 3 Analysis**



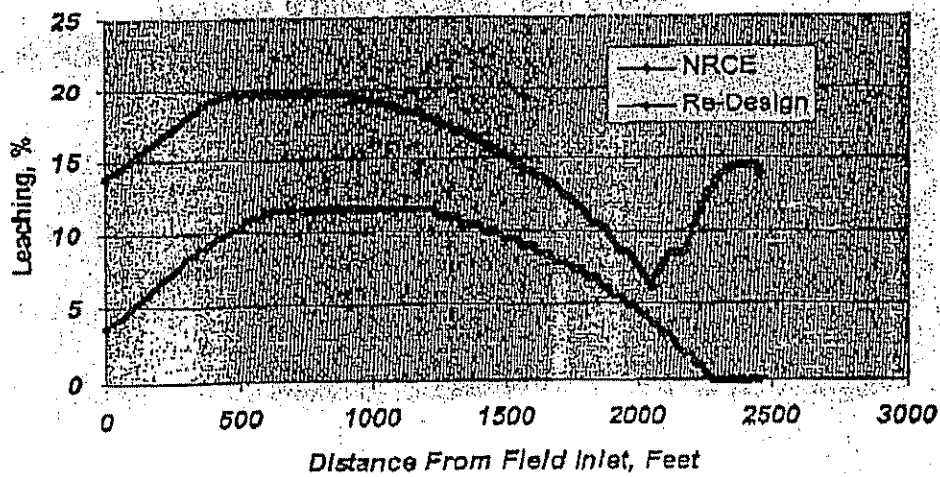
**Figure III-4. NRCE Field 4 Analysis**



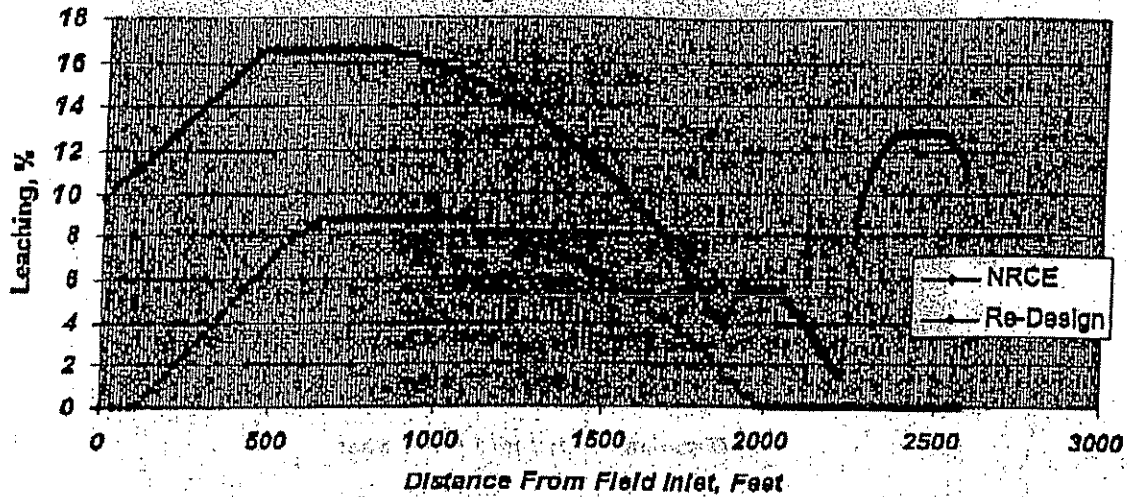
**Figure III-5. NRCE Field 5**



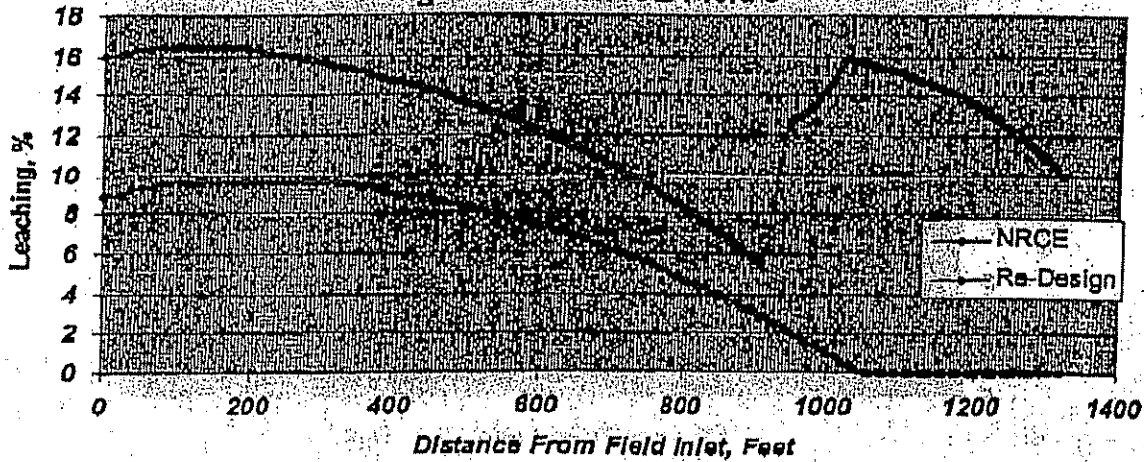
**Figure III-6. NRCE Field 6 Analysis**



**Figure III-7. NRCE Field**



**Figure III-8. NRCE Field 8**



**Figure III-9. NRCE Field 9 Analysis**

